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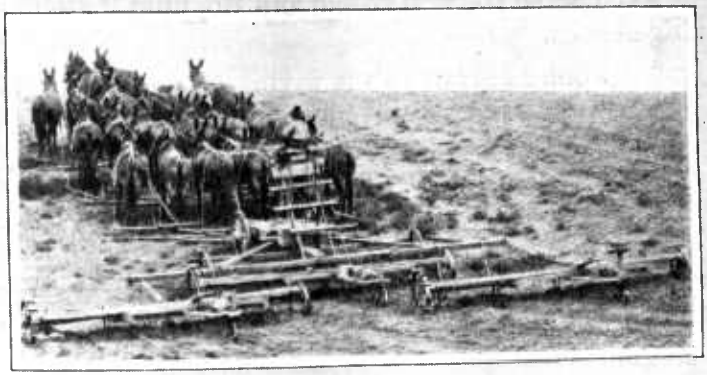
DRY FARMING

METHODS AND PRACTICES IN WHEAT GROWING *in the* COLUMBIA AND SNAKE RIVER BASINS



THIS BULLETIN deals with the dry-farming methods practiced on grain farms in the Pacific Northwest, where the rainfall is less than 15 to 18 inches annually, but it also contains advice helpful to all farmers of that region who practice summer fallowing.

Its purpose is to show the possibility of increasing crop yields in the dry-farming areas by using improved methods and to discuss the practices which have been found most advantageous.

The summer fallow is a feature inseparable from all of these methods. Experiment station investigations conducted continuously under average dry-farming conditions for 12 years at Moro, Oreg., and for 8 years at Lind, Wash., show that the highest yields have been secured by plowing in the early spring and giving enough cultivation after plowing to keep the weeds well under control.

The purposes of summer fallowing and details of the methods by which it is accomplished are given, and the application of these methods to the cultivation of "blow" soils and "nonblow" soils. Methods are suggested for preventing and stopping the blowing of soils.

Attention is given to the saving of man labor by the use of large power units, methods of seeding winter and spring wheat are outlined, and suggestions are made for maintaining the organic matter in the soil.

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DRY-FARMING METHODS AND PRACTICES IN WHEAT GROWING IN THE COLUMBIA AND SNAKE RIVER BASINS[1]

By Byron Hunter
Associate Agricultural Economist, Division of Farm Management and Costs, Bureau of Agricultural Economics

CONTENTS

DRY-FARMING DISTRICTS IN THE PACIFIC NORTHWEST

In the Pacific Northwest are two general dry-farming districts—the Columbia River Basin and the Snake River Basin. Dry-farming has been carried on extensively in the Columbia River Basin for 35 or 40 years. During this time the practice of summer fallowing the land every other year has become general in all localities that have an average annual precipitation of less than 15 to 18 inches. That is, the land is clean cultivated as fallow one year, and produces a crop of grain, usually wheat, the next year. In the more humid districts the land may be summer fallowed once in two years, once in three years, or once in four years.

Summer fallowing is also practiced generally in all localities of the Snake River Basin where crops are grown without irrigation. The land is in a grain crop one year and is fallowed the next.

[1] Acknowledgments are due to the numerous farmers, business men, and county agricultural agents interviewed during the preparation of this bulletin. The author is indebted to D. E. Stephens, H. M. Wanser, and C. E. Hill, superintendents, respectively, of the dry-farming experiment stations located at Moro, Oreg., Lind and Waterville, Wash., and to M. A. McCall, agronomist, Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, for helpful suggestions offered and data furnished in assembling the material for this bulletin. The author is indebted to M. L. Wilson, agricultural economist, Montana State Agricultural College, for the title-page illustration and for Figures 8 and 20, and to A. J. Ogaard, extension agronomist of the same institution, for Figures 4, 6, 15, and 19. A part of this material was issued in 1919 as Farmers' Bulletin 1047.

SOURCES OF INFORMATION

This bulletin is based (1) on an extensive study of the farming methods practiced under dry-farming conditions in the Columbia and Snake River Basins, and (2) on the investigational work done by the experiment stations of Oregon, Washington, and Idaho. The purpose is to show the possibility of increasing the acre yield of wheat on many farms and to discuss the cultural methods which, according to farm experience and experimental data, give the highest yields. Although the bulletin is intended primarily for the districts having an annual precipitation of less than approximately 18 inches, it should be helpful to all farmers of the Pacific Northwest who practice summer fallowing.

DESCRIPTION OF THE REGION

Dry farming is practiced under a wide range of conditions in the Pacific Northwest. In the Columbia River Basin the altitude at which dry farming is carried on varies from approximately 600 feet

FIG. 1.—Good plowing of the heavier nonblow soils. The plow that turned this soil was equipped with a combination rolling coulter and jointer (fig. 2) and a rod for turning under the stubble. Tillage implements slip through the soil more freely if the stubble is well covered

to 3,000 feet, and in the Snake River Basin from 2,100 feet to 6,500 feet. This causes a great difference in the length of the growing seasons in the various localities.

The climate is marked by a wet and a dry season and a limited rainfall. The wet season comes during the winter, and the dry season during the summer. July and August are usually extremely dry. One of the chief difficulties in raising winter wheat is insufficient autumn rains to germinate the seed and get the crop started before the beginning of winter. Torrential rains seldom occur, and little water is lost by surface run-off except when rain falls or a snow melts suddenly upon a frozen surface.

The types of soil used for dry farming vary from heavy silt loams to very fine sand and sandy loams. The prevailing soil type is silt loam. These soils are usually well supplied with the mineral plant-food elements, especially with potash and phosphorus. On the other

hand, the supply of organic matter and nitrogen is generally low. In some localities where the rainfall is scant, much damage is frequently done during the spring and summer because the wind blows and drifts the soil. (Fig. 10.)

The soils that blow and drift require special tillage methods to control them, and are spoken of locally as "blow" soils. For these reasons and for convenience in discussing the cultural methods practiced, the soils are here classified as "blow" soils and "nonblow" soils. The soils that blow constitute a very small part of the total area that is dry farmed.

PURPOSE OF SUMMER FALLOWING

Summer fallowing accomplishes very definite results in the dry farming districts of the Columbia and Snake River Basins, provided the tillage operations are rightly timed and the work is well done. The results accomplished may be briefly summarized as follows:

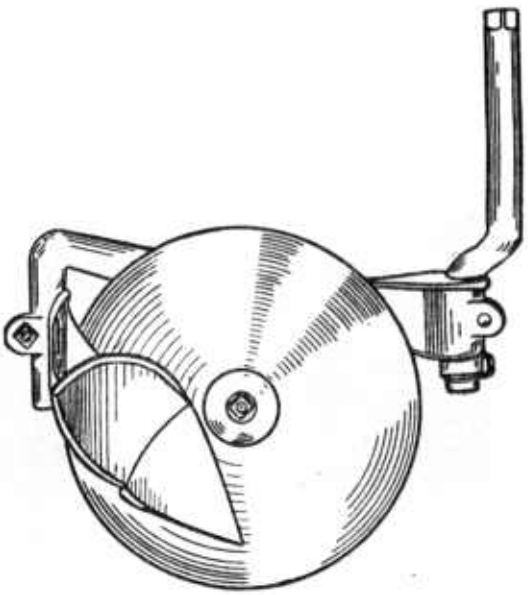

FIG. 2.—A combination rolling coulter and jointer that is attached to the plow beam to assist in turning under heavy stubble

A portion of the rainfall of one winter is stored in the soil and carried over for the use of the crop to be grown the following year (Table 2).—Much of the wheat produced in the Columbia and Snake River Basins is grown with less than 15 inches of annual rainfall, but farm experience and experimental work have clearly shown that this is not enough moisture for profitable farming when a cereal crop occupies the land continuously year after year.

Soil moisture is lost during the fallow season in two ways: First, volunteer wheat and weeds, when allowed to grow, draw heavily on the soil moisture and, second, considerable moisture evaporates from the surface of the ground during the late spring and summer months when the temperature is high and the relative humidity is low. Hence, the primary purpose of summer-fallow tillage is to prevent weed growth and to check evaporation. It is now well understood that tillage accomplishes a great deal more in the way of destroying weeds than in preventing evaporation through the formation of a soil mulch.

Nitrate nitrogen is formed and accumulated in the soil during the summer-fallow season for the use of the future crop.—The dry-

farming soils of the Pacific Northwest are somewhat deficient in nitrogen. This important element of plant food occurs in the soil chiefly as the constitutent of vegetable or organic matter, whereas the growing crop can use it only in the soluble or nitrate form. The organic form of nitrogen is changed to the nitrate or soluble form when the vegetable matter of the soil decays. But in order that decay may take place rapidly, the soil must be kept moist during the spring and summer while it is reasonably warm. The nitrate-nitrogen content of the soil becomes practically exhausted while the crop is growing and maturing because the crop uses the soil moisture rapidly and the ground becomes too dry for much decay to take place.

Summer fallowing prepares an excellent seed bed for the germination of fall-sown wheat.—There are many advantages in growing winter wheat instead of spring wheat in much of the dry-farming districts of the Columbia and Snake River Basins, but because of the scant autumn rains, it is frequently difficult to get a satisfactory stand of winter wheat. When the fall rains are light, it is much easier to

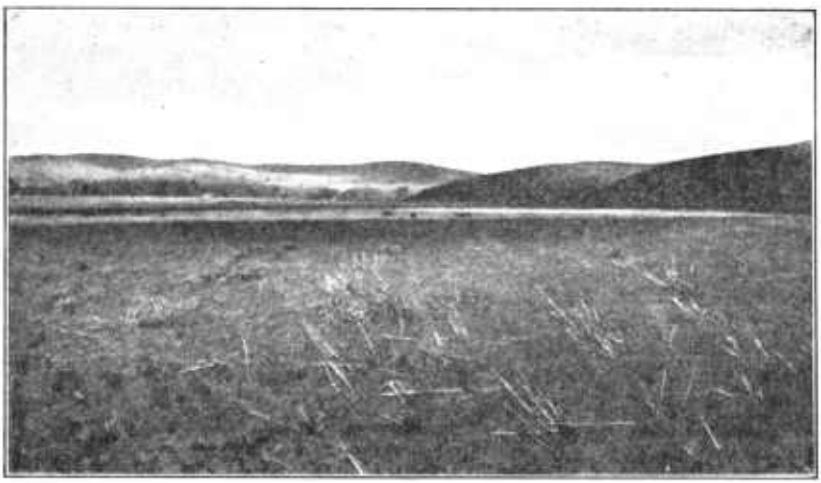

FIG. 3.—Poor plowing of the heavier nonblow soils. The stubble in the surface soil gives much trouble by clogging the knives of such weeders as are shown in Figures 5, 6, and 7

start winter wheat satisfactorily on summer-fallow land that has been plowed early and cultivated enough to keep it free from weeds than on land that has been poorly summer-fallowed.

POSSIBILITY OF INCREASING WHEAT YIELDS

A comparative study of the tillage methods practiced and the yields obtained on individual farms in various dry-farming localities leads definitely to the conclusion that the acre yield of wheat can be increased materially on many farms by changing the methods of summer-fallowing. In the main these changes would be effected by doing the tillage work at the time when it will be the most effective.

The dry-farming experiment stations located at Moro, Oreg., and at Lind, Wash., have been in operation long enough to throw much light on this subject. Some of the more important findings of these stations concerning the relation of summer-fallow tillage to the yield

of wheat are presented in Tables 1 and 2. Conditions at the two stations vary considerably. The altitude at the Moro station is 1,800 feet and that at the Lind station is 1,475 feet. The normal precipitation at Moro is 11.3 inches and at Lind it is 10.6 inches. The soil of the Moro station is a silt loam that is not inclined to blow, whereas that of the Lind station is a very fine sandy loam that is more or less liable to blow unless it is handled with care. Because of these differences the field work at Lind begins three to four weeks earlier in the spring than does the work at Moro.

SOME RESULTS AT THE MORO STATION[2]

The results of the tillage experiments at Moro, given in Table 1, are expressed in average yields of wheat per acre. The experimental plats were plowed at different dates, and no cultivation was done prior to the date of plowing. That is, any volunteer wheat and

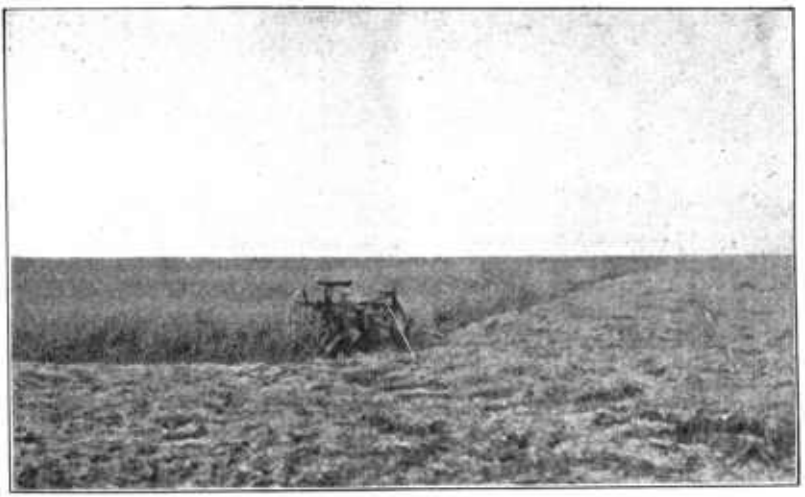

FIG. 4.—Late plowing of land to be summer-fallowed. In this case the heavy growth of weeds has largely nullified the purpose of summer-fallowing by using the available soil moisture and nitrates

weeds that appeared were allowed to grow until the land was plowed. In those cases where the plowing was done as late as June 1 the growth of the weeds and volunteer wheat had usually already made heavy inroads on the supply of soil moisture and nitrate-nitrogen. This, in turn, is reflected in the comparatively low yield of wheat (Table 1).

"Clean cultivation," as used in Table 1, consisted of (1) harrowing twice immediately after the plats were plowed, that is, on the same

[2] The experimental tillage work done at Moro is more fully described in the following publications:

STEPHENS, D. E. EXPERIMENTS WITH SPRING CEREALS AT THE EASTERN OREGON DRY-FARMING SUBSTATION, MORO, OREG. U. S. Dept. Agr. Bul. 498, 38 p., illus. 1917.

——— DRY-FARM CROP ROTATION EXPERIMENTS AT MORO, OREGON. Oreg. Agr. Expt. Sta. Bul. 209, 45 p., illus. 1924.

——— McCALL, M. A., and BRACKEN, A. F. EXPERIMENTS IN WHEAT PRODUCTION ON THE DRY LANDS OF THE WESTERN UNITED STATES. U. S. Dept. Agr. Bul. 1173, 60 p., illus. 1923.

day (2) harrowing again as soon as crop of weeds appeared, usually in about three weeks, and (3) giving enough cultivation after the third harrowing to keep the land free from weeds. A considerable growth of weeds and volunteer wheat usually appeared on the plats that were plowed on April 1 and May 1 and which were harrowed but once immediately after the plowing or which received no cultivation after plowing. To keep the land from becoming foul, the weeds were removed with a hoe or other suitable implement just before they formed seed. The plats that were plowed in the fall remained undisturbed, just as the soil came from the plow, until spring. Enough cultivation to

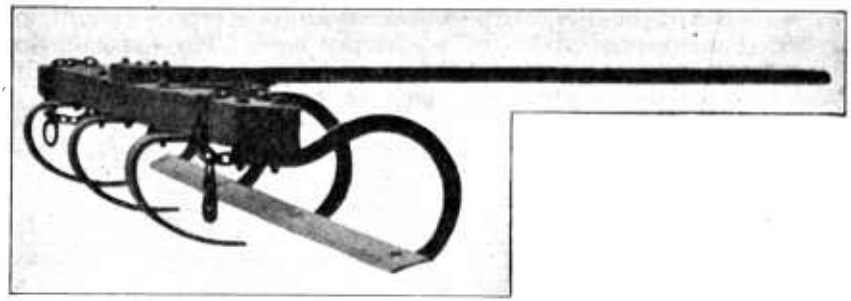

FIG. 5.—A knife weeder, locally called the "gooseneck slicker." This type of weeder is made by blacksmiths in various localities. The driver rides on the tailboard projecting behind and the team is hitched to the chains around the beam. When the knife clogs it is cleaned by stopping the team and raising the knife out of the ground by lifting up the tailboard

keep the plats free from weeds was then given during the spring and summer months.

TABLE 1.—*Twelve-year average yields of Turkey winter wheat in summer-fallow tillage experiments at the Sherman County Branch Experiment Station, Moro, Oreg., 1914–1925*[1]

Kind of tillage and time of plowing	12-year average yield per acre	Kind of tillage and time of plowing	12-year average yield per acre
Spring plowing, with clean cultivation:	*Bushels*	Spring plowing, with no other cultivation:	*Bushels*
Plowed Apr. 1	30.4	Plowed Apr. 1	25.8
Plowed May 1	28.0	Plowed May 1	25.1
Plowed June 1	23.1	Plowed June 1	22.8
Spring plowing, harrowed once:		Fall plowing, with clean cultivation:	
Plowed Apr. 1	26.1	Plowed dry in early fall	27.2
Plowed May 1	25.6	Plowed wet in late fall	24.2
Plowed June 1	22.9		

[1] Compiled from data furnished by D. E. Stephens, superintendent, Sherman County, Oreg., Branch Experiment Station, and from the following bulletin: STEPHENS, D. E., MCCALL, M. A., and BRACKEN, A. F. EXPERIMENTS IN WHEAT PRODUCTION ON THE DRY LANDS OF THE WESTERN UNITED STATES. U. S. Dept. Agr. Bul. 1173, 60 p., illus. 1923.

The information presented in Table 1 emphasizes the importance of plowing the land to be summer fallowed in the early spring and giving enough tillage after plowing to keep the weeds under good control. With clean cultivation after plowing the average yield resulting from April 1 plowing exceeded that of May 1 plowing by 2.4 bushels per acre; that of June 1 plowing by 7.3 bushels; that of dry fall plowing by 3.2 bushels; and that of wet fall plowing by 6.2 bushels. Giving clean cultivation after plowing increased the

average yield from the April 1 plowing by 4.6 bushels per acre; that from the May 1 plowing by 2.9 bushels and that from the June 1 plowing by only 0.3 bushel.

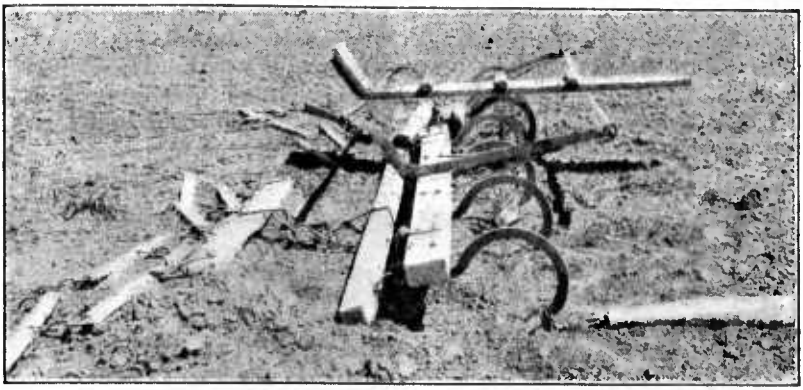

FIG. 6.—Side view of a gooseneck slicker now used in the vicinity of Walla Walla, Wash., and Pendleton, Oreg. The angle iron frame which supports the dumping board makes it possible for the driver to clean the knife while the team is moving, by stepping forward and backward on the dumping board. This is a decided improvement over the slicker shown in Figure 5

Harrowing but once immediately after plowing on April 1, May 1, or June 1 seems to have little effect on the yield of wheat, the greatest increase being one-half bushel per acre from the May 1 plowing.

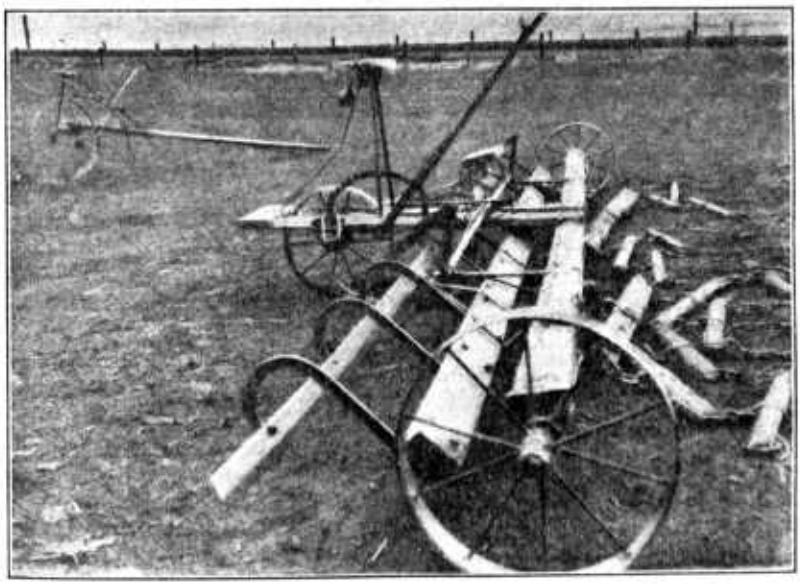

FIG. 7.—A 24-foot gooseneck slicker mounted on three 24-inch steel wheels. The main beam is supported by truss rods. The knife is in two sections, which operate independently in the soil. The lever enables the driver to dump the machine when it clogs and to set the knives to run the desired depth

Unless there are weeds to be destroyed, the cultivation of land plowed as late as June 1 appears to be of little or no value.

SOME RESULTS AT THE LIND STATION[3]

The results of the tillage experiments at Lind, Wash., given in Table 2, are expressed in (1) inches of rainfall conserved, (2) relative amounts of nitrate nitrogen accumulated, and (3) yields of wheat per acre. In this table "clean cultivation" signifies enough cultivation to keep the weeds under good control. The soil of the Lind station is light and somewhat inclined to blow. For this reason little or no cultivation is given after plowing in the spring unless there are weeds to be destroyed.

FIG. 8.—A 50-foot harrow pulled by a 14-mule team. This team harrows from 80 to 100 acres per day. The driver does the work that formerly required two men when 6-mule teams were used

TABLE 2.—*Eight-year average annual rainfall conserved, average relative nitrate nitrogen accumulated, and average acre yield of wheat in summer-fallow tillage experiments at the Adams Branch Experiment Station, Lind, Wash., 1918–1925*[1]

Character and time of tillage	Average rainfall conserved	Average[2] relative nitrate nitrogen accumulated	8-year average acre yield
	Inches	*Per cent*	*Bushels*
Spring plowing—No cultivation before plowing; clean cultivation after plowing:			
Plowed Mar. 1–10	3.78	100	12.4
Plowed Apr. 10–20	3.66	83	12.0
Plowed May 20–31	2.90	60	9.5
Fall plowing—Left rough until spring; then clean cultivation:			
Plowed dry during September	3.23	86	9.9
Plowed wet during November	3.31	91	10.5
Disked Mar. 1–10 before plowing; clean cultivation after plowing:			
Plowed May 20–31	3.34	88	10.9
Disked twice (Mar. 1–10 and Apr. 10–20):			
Clean cultivation after last disking	3.78	83	11.7

[1] Compiled from data furnished by H. M. Wanser, superintendent, Adams Branch Experiment Station, Lind, Wash.

[2] Nitrate nitrogen accumulated by plowing Mar. 1–10, with clean cultivation equals 100.

The importance of plowing in the early spring, land that is to be summer fallowed, that is, before the volunteer wheat and weeds have made enough growth to draw heavily on the soil moisture, and then giving enough cultivation to keep the weeds well under control is

[3] The experimental work done at Lind is more fully described in the following bulletins: MCCALL, M. A., and HOLTZ, H. F. INVESTIGATIONS IN DRY-FARM TILLAGE. Wash. Agr. Expt. Sta. Bul. 164, 51 p., illus. 1921.

——— and WANSER, H. M. THE PRINCIPLES OF SUMMER-FALLOW TILLAGE. Wash. Agr. Expt. Sta. Bul. 183, 77 p., illus. 1924.

further emphasized by the facts given in Table 2. With no cultivation before plowing, and clean cultivation after plowing, the eight-year average yield from early March plowing exceeded that from plowing the middle of April by 0.4 bushels per acre; that from late May plowing by 2.9 bushels; that from dry fall plowing by 2.5 bushels, and that from wet late fall plowing by 1.9 bushels.

The average yield from disking early in March and plowing late in May, with clean cultivation after plowing, was 1.5 bushels below that from early March plowing with clean cultivation. Likewise the average yield from disking twice (early in March and the middle of April), with clean cultivation after the last disking, was 0.7 bushels below that of early March plowing with clean cultivation.

Measured in rainfall conserved, early March plowing, and disking twice instead of plowing, were highest and equal in results; plowing the middle of April brought the second highest results and plowing late in May brought the lowest.

When judged by the relative amounts of nitrate nitrogen accumulated, the early March plowing was most successful; late fall plowing was second; and late May plowing was the lowest of all the tests. The quantity of nitrate nitrogen accumulated by plowing late in May was only 60 per cent of that accumulated by plowing early in March.

FIG. 9.—A six-horse team disking stubble land

The information presented in Tables 1 and 2 shows clearly the importance of early spring tillage in summer fallowing. The important object in view is the establishment of a soil mulch before the volunteer wheat and weeds have made enough growth to draw heavily on the soil moisture. The data also show that it is highly important to give enough cultivation to keep the weeds well controlled during the summer-fallow season. The possibilities of increasing the yield of wheat on many farms by early spring tillage and by keeping the land free from weeds is apparent when it is remembered that much of the land now fallowed each year is plowed late in the season after the weeds and volunteer grain have grown enough to make heavy inroads on the supply of soil moisture and nitrate nitrogen. Figure 4 shows this kind of plowing.

METHODS OF SUMMER FALLOWING

Summer fallowing is a loosely used term. To many farmers it means plowing the land to be fallowed, regardless of any other tillage operations that may be performed, either before or after the land is plowed. Farmers frequently say they are "through summer fallowing" when they have finished plowing. As used in this bulletin the term "summer fallowing" includes all of the tillage operations performed during the fallow year. Plowing is only one of these operations.

The soil conditions and the annual and monthly rainfall vary too widely in the Columbia and Snake River Basins to make it possible to give uniform directions for handling all the land that is to be summer fallowed. For this reason no attempt is made in the following pages to say definitely what tillage operations should be performed. But methods are described that, according to the experience of very successful farmers, are giving the most profitable returns. As the season varies the tillage operations vary.

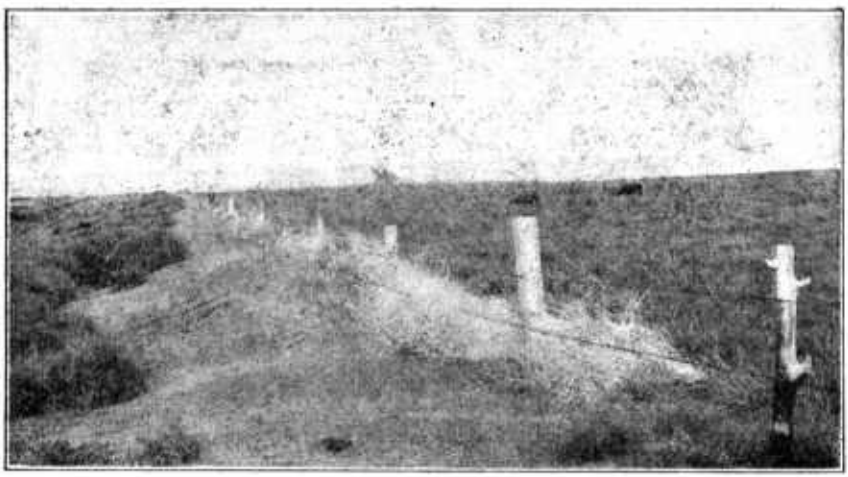

FIG. 10.—A sand dune that was blown into the lane from the field to the right. The weeds collected along the wire fence and stopped the sand

The farm operator should have definitely in mind the principal objects to be accomplished by summer fallowing. With these objects in view, and with the equipment at his disposal, he should perform such tillage operations as will best accomplish the desired results.

METHODS FOR USE ON NONBLOW SOILS

The soils classified here as nonblow soils vary widely. In the drier localities they grade (imperceptibly) into the soils that do blow. In the more humid districts they are heavy silt loams that receive enough precipitation to saturate them practically every winter. On the one extreme, some attention must be given to the possibility of the soil blowing. On the other extreme, this question need receive no consideration whatever. The following are some of the methods in most common use for summer fallowing the soils that are not subject to blowing.

SPRING PLOWING; THE FIRST OPERATION

The spring-plowing method is used more extensively than any other. The date of plowing may vary from early spring until late in June. The majority of farmers realize the advantage of early plowing and begin as soon as the soil is in good condition or immediately after finishing the seeding of the spring grain. In the higher altitudes the soil remains in fairly good condition for plowing for about 30 days. As the altitude decreases the length of the plow season increases, and in parts of the Columbia Basin good plowing may be done during a period of about 40 days. In order to be good plowing the job must be completed before the volunteer wheat and weeds have made much growth, and the stubble and weeds must be well covered. Figure 1 shows a good job of plowing where the stubble is fairly heavy; Figure 2 shows a plow attachment that assists materially in turning under heavy stubble; and Figure 3 shows a poor job of plowing of nonblow soils because the stubble is only partially covered.

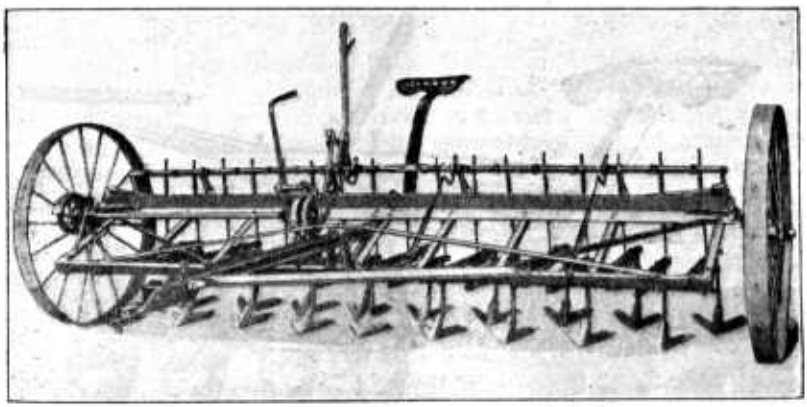

FIG. 11.—Front view of a 12-foot duck-foot cultivator. This implement is used instead of the plow on light soils that are more or less subject to blowing. The shovels can be set to run the desired depth by means of the lever. About 70 per cent more land is covered per horse with the duck-foot cultivator than with the plow. Figure 19 shows this implement in action

Farmers who plow early usually try to do enough cultivation after plowing to keep the weeds well controlled. The first crop of weeds that comes after plowing is usually destroyed with the spike-tooth harrow. (Fig. 8.) On the lighter nonblow soils, which are likely to become too finely pulverized by much cultivation, many farmers prefer to delay the first harrowing for a few days after the land is plowed in order to let the clods dry and harden and to let the weeds start. In this case the land is harrowed when the weeds are white in the soil or just as they are coming through the surface of the ground. Enough subsequent cultivation is then given to keep the land free from weeds. Some form of knife weeder is generally used on the heavier soils, and the rod weeder is used on the light soils. Figures 5, 6, and 7 show three types of knife weeders and Figures 15, 16, and 17, three types of rod weeders.

EARLY SPRING DISKING BEFORE PLOWING

Many farmers prefer to disk the land that is to be summer fallowed before it is plowed. (Fig. 9.) The disking is done in the early spring or as soon as the seeding of the spring grain has been finished. By destroying the first crop of weeds when they are small, and forming a loose surface mulch, the disking causes the soil to remain in good condition for plowing several weeks longer than it otherwise would. In some cases the land is disked twice before it is plowed, the second disking being done after a second crop of weeds has started. To be effective, disking must be done when the weeds and volunteer wheat are small. For that reason the period for early spring disking, when that is the first tillage operation, is much shorter than that for plowing. After the land is plowed, most farmers try to give enough cultivation to keep the land free from weeds.

Farmers generally have two objects in view when this method of fallowing is used. The first is to delay the plowing so late in the

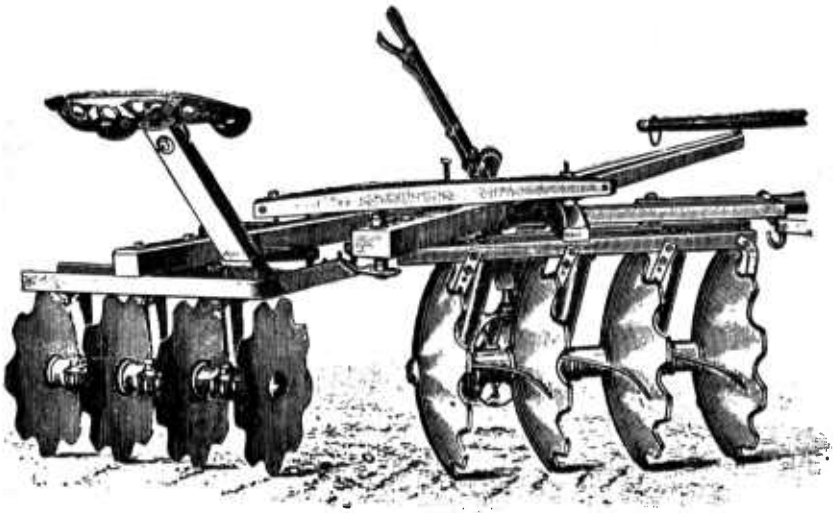

FIG. 12.—The right lap, also called the right-lap plow. This implement turns the soil more completely than a disk harrow, but not so completely as a plow. It has been used rather extensively instead of the plow on light soils

season that no weed seed will germinate, thus eliminating the necessity of tillage during the busy harvest season. The second is to permit the soil to go into the winter loose and open as it leaves the plow. This is considered especially desirable by the growers of spring wheat.

SUMMER-FALLOWING WITHOUT PLOWING

In localities of scant rainfall where crop yields are usually relatively light, considerable summer fallowing is done each year without using the plow. Under this method the disk harrow and right lap (figs. 9 and 12) have been used most extensively for forming the surface mulch; recently the duck-foot cultivator has been introduced for this purpose. (Fig. 11.) When this method is used the land to

be summer fallowed is cultivated with the disk harrow, right lap, or duck foot in the early spring. Light soils may be cultivated as soon as the frost is out of the ground. If the first cultivation forms a mulch of the desired depth, about 5 inches, the weeds are then controlled with the rod weeder. If, on the other hand, the mulch is not deep enough for the operation of the rod weeder, a second cultivation is given with a disk, a right lap, or a spring-tooth harrow. (Figs. 9, 12, and 13.) Table 2 shows that this method at the Lind Station stood third in yield per acre (0.7 bushels per acre below the highest) and equaled any other method in the conservation of moisture.

FALL PLOWING

A limited number of farmers fall-plow the land to be fallowed the following season. The land may be plowed dry or wet, depending upon the amount of rain that comes during the fall months. The soil is allowed to pass through the winter as it comes from the plow. In the spring a mulch is formed with the disk or spring-tooth harrow. In most instances the weeds are then controlled with the rod or knife weeder.

This method is practiced but little, except in certain localities that have relatively high altitudes. It is probably a good practice in localities where the ground is covered with snow most of the winter and where considerable snow melts over frozen soil, in which case the loose, open, fall plowed land probably saves more moisture than does unplowed stubble land. The experimental work at the Lind Station indicates, however, that more water is absorbed if the stubble is allowed to pass through the winter without being disturbed either by disking or by plowing. Where land is badly infested with Russian thistles, which grow in the stubble after harvest, fall plowing or disking may be advisable.

A COMBINATION OF METHODS

If the acreage to be summer-fallowed on a given farm is greater than can be handled efficiently with the available equipment, a combination of methods may be used in order to get the work done in good season. The first two methods described above are frequently used on the same farm. In this case about half of the land to be fallowed is disked as early as possible in the spring. The undisked land is then plowed first and the disked portion last. The disking, it is claimed, lengthens materially the period during which a good job of plowing may be done.

If the plowing can not be finished in good season by a combination of the first two methods it may be advisable to plow a portion of the land that is to be fallowed in the fall. Dry fall plowing at the experiment station at Moro, Oreg., has given yields almost equal to those obtained by plowing May 1 and much higher than those obtained by plowing June 1 where no cultivation was given before plowing and clean cultivation was given after plowing. Much the same results were obtained at the experiment station at Lind, Wash. Fall plowing enables the farm operator to increase considerably the area handled per man and per unit of equipment.

METHODS FOR USE ON BLOW SOILS

The methods used in sumer fallowing the soils that are liable to blow vary considerably in different localities and even in the same locality. In addition to conserving moisture and forming and accumulating nitrates, these soils must be handled in such a way as to prevent their blowing. This is done by performing the tillage operations that will leave the stubble and trash on the surface of the ground and make clods. The soil should be pulverized as little as possible. Stubble, trash, and clods on the surface of the ground tend to keep the soil from blowing, whereas pulverizing the soil puts it in condition to blow readily. Figure 19 shows a desirable surface condition for light soils.

In the lower altitudes, where the soils are light and more or less subject to blowing, the land to be summer fallowed is usually disked in the early spring. (Fig. 9.) If the mulch formed by the first

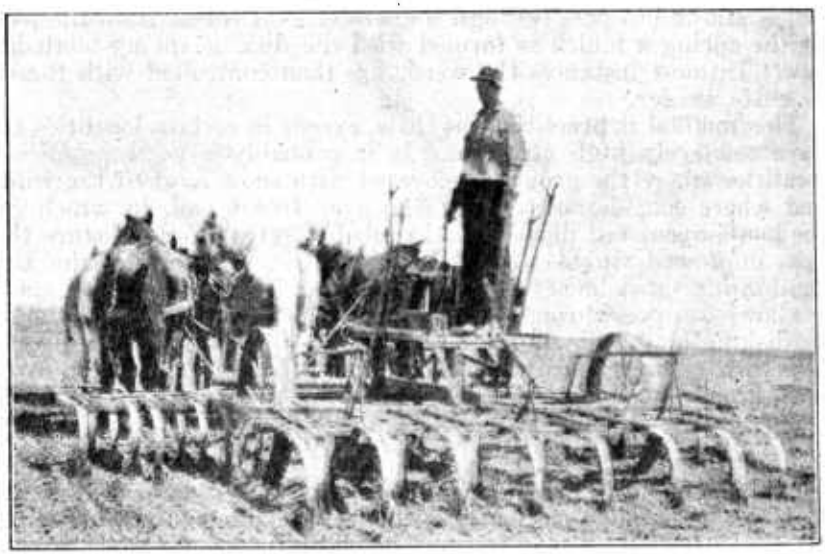

FIG. 13.—A spring-tooth harrow is an excellent implement to use instead of the spike-tooth harrow on soils that are inclined to blow. This implement brings the clods, stubble, and other trash to the surface, and this, in turn, tends to prevent the soil from blowing

disking is not deep enough for operating the rod weeder (about 5 inches) the land is given a second disking as soon as the weeds appear. After a satisfactory mulch is established the weeds are usually controlled with a rod weeder. The mulch is frequently formed with the right lap. (Fig. 12.) Some farmers prefer to use the spring-tooth harrow (fig. 13) instead of the disk for the second cultivation in forming the surface mulch.

Where the mulch is formed with a disk harrow, the soil is likely to become too finely pulverized. For this reason some farmers prefer to form the mulch with a spring-tooth harrow, which leaves the stubble and trash on the surface and which is likely to form more clods than the disk. Recently the duckfoot cultivator (figs. 11 and 19) has been introduced. This implement can be set to run the desired depth for forming the mulch. In general, wide flat shovels

are used, which operate under the surface of the ground. This implement does not pulverize the soil unduly, and it leaves the trash on the surface.

Fall-plowing the land that is more or less subject to blowing is now becoming a common practice in some of the higher altitudes. The soil remains over winter in the same rough condition as when it comes from the plow. In the spring no cultivation is given until it is necessary to destroy weeds and volunteer wheat. By this time

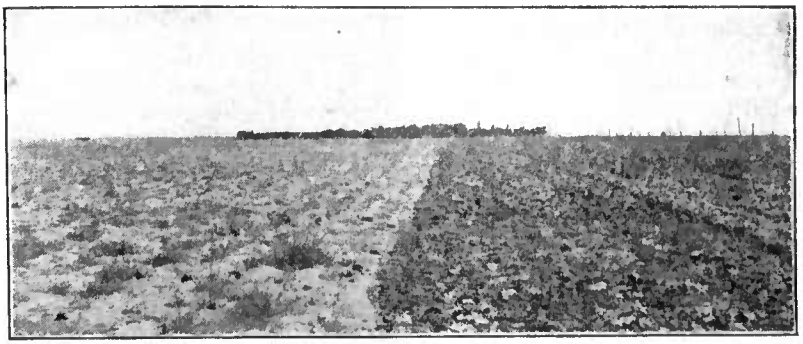

FIG. 14.—The work of a rod weeder on very light soil. The area to the right has been cultivated, while that to the left has not. Note the clods on the surface of the land that has been cultivated

the soil is usually well crusted, and a cloudy mulch is formed with a spring-tooth or duckfoot implement. Weeds are then controlled with the rod weeder. The work of rod weeders is shown in Figures 14 and 18.

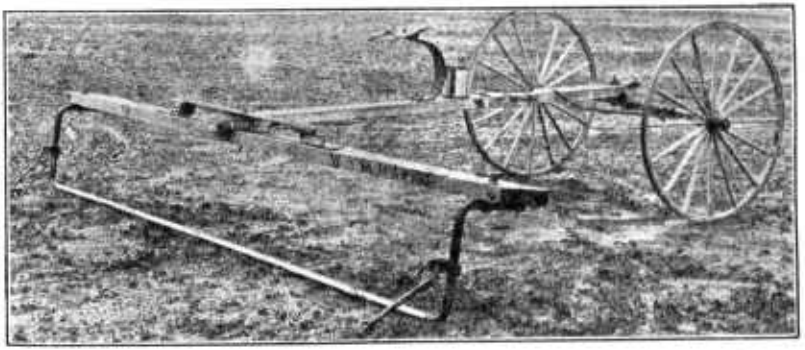

FIG. 15.—A cheaply constructed single-rod weeder that is used in central Washington on light soils that are subject to blowing. The large 1½-inch rod runs at the bottom of the soil mulch or furrow slice. Stubble and trash do not tend to collect on a large rod so much as on one of smaller diameter. The driver rides the cart, and the tongue of the cart holds the weeder in proper position

PREVENTING THE BLOWING OF SOILS

Drilling the seed wheat should be the last operation when land is seeded that is liable to blow. A hoe drill should be used when possible. The drill should be driven at right angles to the direction of the prevailing wind. The hoes of the drill ridge the surface and raise clods to the surface. The ridges tend to hold the fine particles of the soil until the wheat becomes established.

If land that is to be seeded to spring wheat is liable to blow, the surface soil may be puddled and a layer of clods formed by cultivating with a spring-tooth harrow or shovel cultivator in the early spring when the soil is wet. Another method by which such land can be prevented from blowing is by sowing the wheat with a hoe drill in the early morning when a crust is frozen on the surface of the ground. The hoes of the drill should be set as far ahead as possible, and the team should be driven slowly in order to give the drill a better chance to break up the frozen crust. The chunks of frozen soil make clods when they thaw and dry.

If land that has been seeded to winter wheat is liable to blow, it may be treated in either of two ways: (1) If the wheat is well enough rooted to stand it, the land may be harrowed when wet in the early spring in order to puddle the surface soil and make clods, or (2) if the wheat is not well enough rooted to stand the harrowing, the area that is liable to blow may be covered with straw or manure. If available a straw spreader or manure spreader should be used.

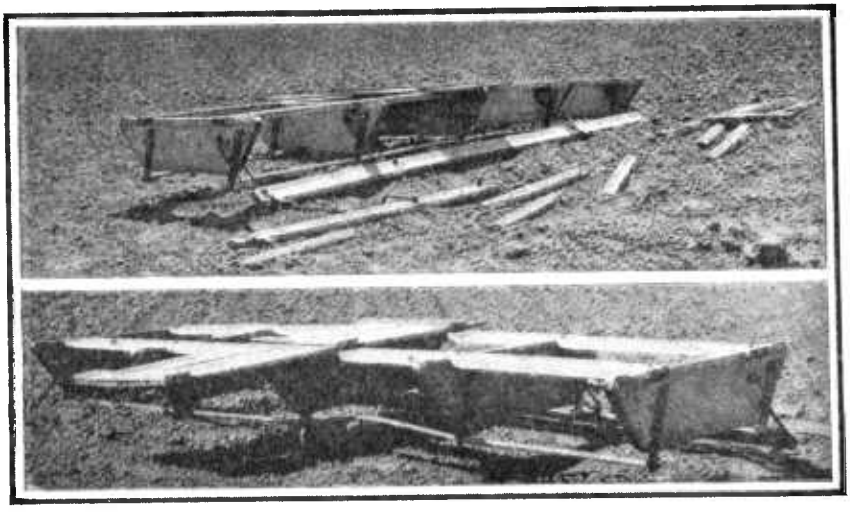

FIG. 16.—A weeder with two stationary rods. The front view is shown above and the rear view below. This weeder is 12 feet long. It is usually drawn by six horses. The runners are 46 inches long on top, 31 inches long on the bottom, and 11 inches wide. They are shod with iron or steel. The rods are 28 inches apart and are placed about 2 inches below the bottom of the runners. When the driver stands on the back end of the tailboard, which is the usual position, the back rod is in the ground. By quickly shifting his position to the front of the implement, and vice versa, the driver can dump or clean the weeder without stopping or making skips. This is a distinct advantage over the single-rod weeder

Excellent results have been obtained in redeeming land that blows badly by growing rye and using it for pasture for two years. The rye may be sown on land that has been summer fallowed or it may be sown in the stubble and covered by disking during the fall or early winter. The rye usually volunteers the second year when used for pasture, but seed may be sown in the fall and covered with the disk harrow. When used for pasture for two years the soil usually becomes sufficiently packed to stand summer fallowing again with but little danger of blowing.

SUGGESTIONS FOR STOPPING SOIL BLOWS

If a soil once begins to blow the matter should receive prompt attention. When the blow begins the area affected is usually small, and prompt attention and a little work will usually stop it. A delay of a few hours or days may mean an increase in the area affected, and much damage may be done not only on the farm where it starts but on neighboring farms.

One of the most effective ways of stopping a blow is to spread straw or manure over the affected area as soon as the blow is discovered. The worker should begin on the windy side of the area and work with the wind. The straw can be held in place by running a disk harrow over the area covered, with the disks set perfectly straight. Spreading straw or manure on the surface is about the only way of stopping a blow where the soil is very sandy.

Blows can usually be controlled in the early stages of their development by cultivating with a spring-tooth harrow, shovel cultivator, or empty hoe drill. The implement should be driven at right angles to

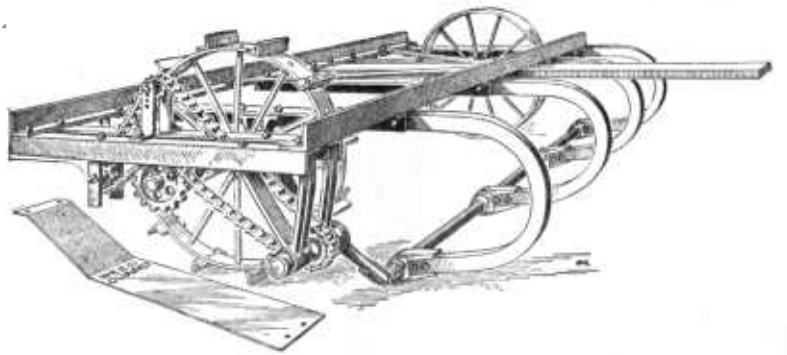

FIG. 17.—A late type of revolving-rod weeder. The rod turns under the surface of the ground in the opposite direction to that of the drive wheel. The revolving of the rod prevents the weeder from clogging, and this feature makes it one of the most satisfactory weeders to use on trashy, blow soils. The draft of this implement is considerably greater than that of a stationary-rod weeder

the direction of the prevailing wind in order to let the drifting sand fall into the furrows. But if there are no clods to be brought to the surface, such cultivation will do little or no good.

Land that is beginning to blow can usually be controlled or held in check by plowing furrows across the affected area at right angles to the direction of the prevailing wind. The furrows should be from 1 to 2 rods apart. The furrows catch the sand and keep it from traveling on the surface of the ground. Furrows do little good if the soil is mostly sand.

SEEDING WINTER WHEAT

To avoid the difficulty of harvesting wheat infested with "tumbling" or "Jim Hill" mustard, the seeding of winter wheat is usually postponed until enough autumn rains have fallen to start the mustard. The seeding of the wheat is usually delayed for several days to permit the mustard seed to germinate. The young mustard plants are

then killed with a spike-tooth harrow or other suitable implement, and the wheat is drilled immediately.

If moisture conditions are favorable the seed should be sown from 1 to 2 inches deep. If the seeding is done late in the fall the seed should be sown very shallow. If another crop of weeds starts at the same time the wheat germinates, the land may be harrowed again when the sprouts on the wheat kernals are not more than an inch long. If enough rain does not come to germinate the mustard and get the wheat started before cold weather sets in, the majority of farmers think spring wheat should be grown instead of winter wheat.

SEEDING SPRING WHEAT

Land that has been summer fallowed the previous season may be seeded to spring wheat by either of two methods.

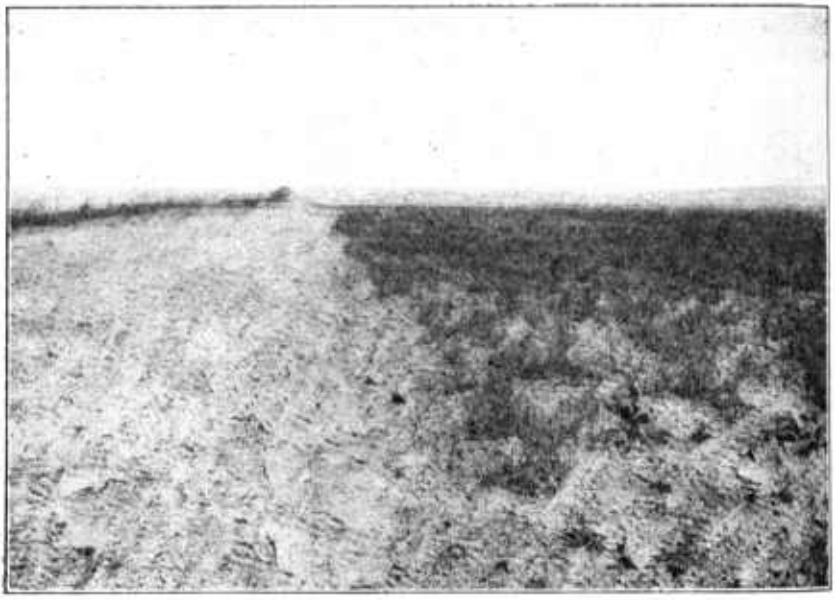

FIG. 18.—The work of the revolving-rod weeder on summer-fallow land that is infested with Russian thistles. The area to the left has been cultivated, and that to the right has not. Note how completely the large weeds were destroyed.

With a hoe drill the wheat is sowed about 2 inches deep in the early spring as soon as the soil is in good working condition, drilling the wheat being the first operation performed. Light soils that are liable to blow may be seeded as soon as the frost is out of the ground. The field should be given a thorough harrowing before the wheat has germinated enough to be injured by such treatment. The hoe drill is preferred to the disk drill because the former cultivates the soil better, but the disk drill does better than the hoe drill on very trashy land. The wheat is drilled before harrowing in order to get the seeding done early and to give the wheat the start of the weeds that may come later.

By the second method the land is harrowed thoroughly (usually twice) before the grain is sown, and again once or twice after it is

sown. To destroy all the weeds possible, the harrowing after seeding may be delayed until the sprouts on the wheat grains are about 1 inch long.

Whichever method is used it should be the aim to germinate and kill a crop of weeds at the time of seeding. If there are weeds that the drill and harrow will not destroy, a knife or rod weeder should be used before the seed is sown. In some instances the ground packs so firmly that it is necessary to form a surface mulch with the disk, spring-tooth harrow, or shovel cultivator.

THE USE OF LARGE POWER UNITS[4]

The use of large power units, experience has shown, is one of the most practicable means of increasing profits on many of the farms of these basins where wheat is produced extensively by the summer-fallow system, for large power units make it possible for one man to do the work of two men and sometimes that of three men. Large power units are shown in Figures 8, 20, and 21 and in the cover-page

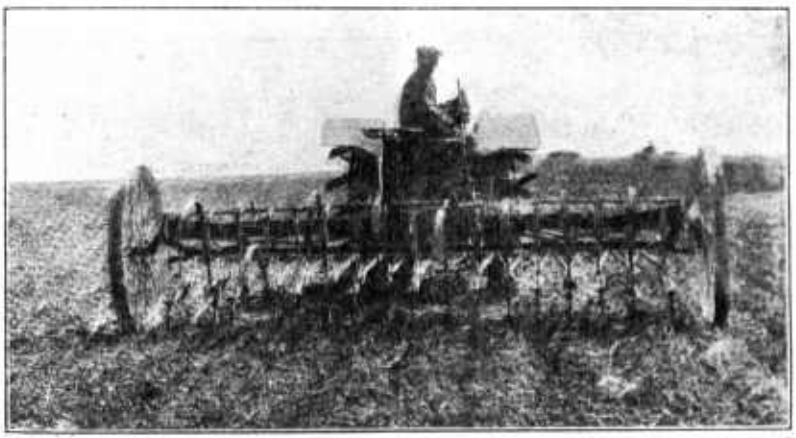

FIG. 19.—A good surface condition for light-soil summer fallow, as left by the duck's foot cultivator. The surface is ridged and covered with clods, and the stubble is mixed with the surface soil

illustration. The latter shows a 20-mule team pulling three 12-foot revolving-rod weeders. The driver of this team does the work that formerly required three men. In districts where the rainfall is scant the yield of wheat is determined largely by the supply of soil moisture available for the growing crop. Hence the possibility of increasing the acre yield of wheat is limited, and it has been found more practicable where the returns per acre are low to increase the acreage farmed per man by the use of large power units than to increase the acre yield.

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[4] In both the Columbia and Snake River Basins considerable farm work is done with tractors. Those interested in the use of tractors on wheat farms should consult the following bulletins:

WASHBURN, R. S., and SCUDDER, H. D. COST OF PRODUCING WINTER WHEAT AND INCOMES FROM WHEAT FARMING IN SHERMAN COUNTY, OREG. U. S. Dept. Agr. Bul. 1446, 40 p., illus. 1927.

——— and SCUDDER, H. D. COST OF USING HORSES, TRACTORS, AND COMBINES ON WHEAT FARMS IN SHERMAN COUNTY, OREG. U. S. Dept. Agr. Bul. 1447, 44 p., illus. 1926.

For a more complete history of the development and use of big teams see WILSON, M. L. BIG TEAMS IN MONTANA. Mont. Agr. Col. Ext. Pub. 70, 111 p., illus. 1925.

In the beginning of wheat raising in the Columbia and Snake River Basins by dry-farming methods the small teams used were at first 2 and 3 horse teams, and 12-inch and 14-inch walking plows were used. These were soon replaced by 5 and 6 horse teams and 12-inch and 14-inch 2-bottom gang plows. In turn these were replaced largely by 8 to 10 horse teams and 14-inch 3-bottom plows. Although 12-horse teams and 16-inch 3-bottom plows have been used considerably during recent years, the 8 to 10 horse team pulling a 14-inch 3-bottom gang plow is in most general use at the present time. Of late years, there has been a tendency to double this unit, one man driving a 16-horse, an 18-horse, or a 20-horse team which pulls two 14-inch 3-bottom gang plows. (Fig. 20.) Tractors are used on many large wheat farms, especially for plowing and drawing combines. (Fig. 21.)

If large power units are to be used economically, the other tillage implements used in addition to the plow must be adapted to the size of power units. On a large farm in the Columbia Basin, where the rainfall is scant and where it is necessary to handle the soil carefully to prevent it from blowing, power units consisting of 16 mules each

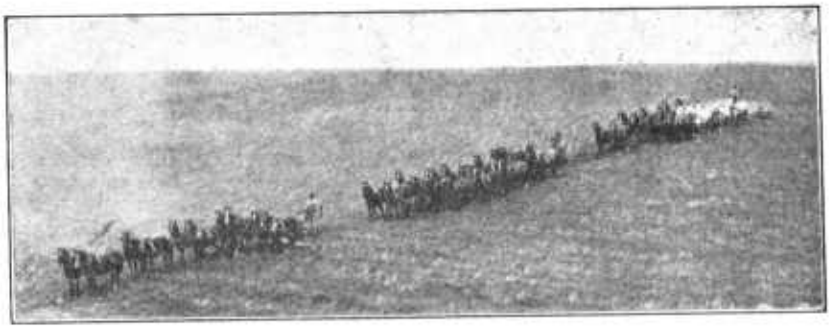

FIG. 20.—Three plow teams, one of 10 horses and two of 18 horses each. The front team pulls one 14-inch 3-bottom gang plow, whereas each of the other teams pulls two 14-inch 3-bottom gaug plows. Each driver of the 18-horse teams plows twice as much land per day as does the driver of the 10-horse team

are used, except during the seeding season, when two 16-mule teams are converted into three 10-mule teams.

The implements drawn by a 16-mule team are a 12-foot duckfoot cultivator, or two 12-foot revolving-rod weeders, or a 16-foot combine harvester. A 10-mule team pulls two 16-hoe drills or a 40-foot harrow.

MAINTAINING THE ORGANIC MATTER OF THE SOIL

The organic matter of the soil is being affected in two ways: Through the process of decay, on the one hand, it is gradually disappearing; by the addition of stubble, weeds, and roots of both weeds and the crops grown, it is being increased. Which of these two processes is taking place the more rapidly is a question that will vitally affect the future productiveness of the soil. In comparing typical eastern Oregon wheat soils with like virgin soils, the Oregon Agricultural Experiment Station [5] found that the carbon or organic

[5] BRADLEY, C. E. THE SOILS OF OREGON. Oreg. Agr. Expt. Sta. Bul. 112, 48 p. 1912.

content of the soils, which had been used for raising wheat for 17 to 25 years, had decreased approximately 23 per cent. In summarizing the results of a similar study of eastern Washington soils the Washington Agricultural Experiment Station [6] makes the following statement:

> Assuming that the observed differences between adjacent virgin and cultivated lands are due to the effects of the cropping of the land, it may be said that these results show, in general, a significant reduction in the organic constituents of the soil by the present methods of dry-farming operations.

These investigations were not exhaustive, but they tend to show that the vegetable matter of the dry-farmed soils is decaying and disappearing more rapidly than it is being added. If this is true, and if this wasting of the resources of the soil is allowed to continue indefinitely, the time will undoubtedly come when crop yields will be seriously reduced and farming may become unprofitable. More

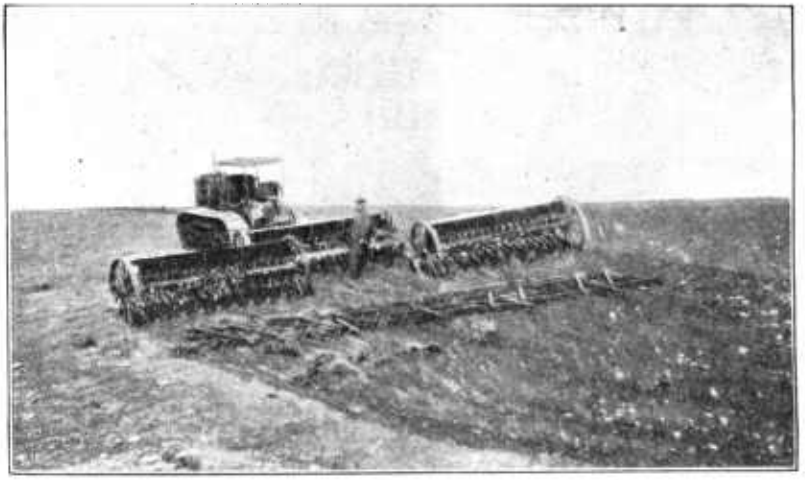

FIG. 21.—A 40-drawbar horse-power tractor pulling three 10½-foot drills and a spike-tooth harrow. Two men with this equipment can drill about 70 acres of wheat per 10-hour day

thorough cultivation of the summer-fallow will result (for a time at least) in increased yields on many farms, but it will also cause a more rapid decay and depletion of the organic matter.

In northern Idaho and in the extreme eastern portion of Washington, where the average annual rainfall ranges from 20 to 26 inches and where the stubble plowed under is short because the grain is cut with the binder, there has apparently been a marked decrease in the vegetable matter of the soil. This is clearly shown by the texture of the soil. When first put under cultivation the soils of this district were mellow and friable; now they are much more inclined to wash, run together, and break up into clods when plowed. In districts where relatively tall grain is cut with the header or combine harvester, thus leaving a heavy stubble on the ground, it may be that new vegetable matter is being added to the soil as rapidly as

[6] THATCHER, R. W. THE NITROGEN AND HUMUS PROBLEM IN DRY FARMING. Wash. Agr. Expt. Sta. Bul. 105, 16 p. 1912.

other vegetable matter in the soil is decaying and disappearing, but this is not very probable.

A balance should be maintained between the organic matter of the soil and the annual precipitation; that is, vegetable matter should be added at about the rate at which it decays. Good judgment is required to maintain this balance. The too-rapid addition of vegetable matter will cause one of two things to happen. If there is not enough moisture to cause the added vegetable matter to decay, the soil will dry out rapidly. If conditions are favorable for decomposition, enough decay may take place to induce the crop to grow vigorously in the early part of the season, and then to "burn" when the soil moisture becomes exhausted.

If the supply of vegetable matter is allowed gradually to become low through the processes of decay, a soil condition will be reached eventually that will be most difficult to correct. For this reason the

FIG. 22.—Burning Russian thistles in the early spring preparatory to plowing. An iron spike-tooth harrow is hitched to a wagon or team by means of a long chain. The thistles that collect in the harrow are ignited and burn as the team moves forward. Note the bare ground in the foreground over which the "fire harrow" has passed

problem of maintaining the vegetable matter of the soil should receive due consideration.

It is probable that vegetable matter can be added most satisfactorily by attaching a straw spreader to the combine harvester where the grain is cut with that machine, or by freely using the straw spreader where the grain is threshed with a stationary machine. The practice of burning the stubble and weeds should be resorted to only in extreme cases, where the stubble and weeds are too heavy to be plowed under. (Fig. 22.) In districts that have an annual rainfall of more than 20 inches and a claylike subsoil (northern Idaho and parts of eastern Washington), the soil should be improved by growing leguminous crops like peas, clover, alfalfa, and vetch, and by feeding more livestock.

U. S. GOVERNMENT PRINTING OFFICE: 1927